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# Towards an Animal-Centred Ethics for Animal-Computer

## Interaction

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### Abstract

The emerging discipline of Animal-Computer Interaction (ACI) aims to take what in HCI is known as a *user-centred* approach to the design of technology intended for animals, placing them at the centre of the design process as stakeholders, users, and design contributors.

However, current regulatory frameworks for the involvement of animals in research are not animal-centred, regarding them as research instruments, unable to consent to procedures that may harm them, rather than consenting research participants and design contributors. Such frameworks aim to minimise the impacts of research procedures on the welfare of individual animals, but this minimisation is subordinated to specific scientific and societal interests, and to the integrity of the procedures required to serve those interests. From this standpoint, the universally advocated principles of replacement, reduction and refinement aim to address the ethical conflicts arising from the assumed inability of individual animals to consent to potentially harmful procedures, but such principles in fact reflect a lack of individual centrality.

This paper makes the case for moving beyond existing regulations and guidelines towards an animal-centred framework that can better support the development of ACI as a discipline.

Firstly, recognising animal welfare as a fundamental requirement for users and research

participants alike, the paper articulates the implications of a *welfare-centred ethics framework*.

Secondly, recognising consent as an essential requirement of participation, the paper also defines criteria for obtaining animals' *mediated* and *contingent consent* to engaging with research procedures. Further, the paper argues for the methodological necessity, as well as the ethical desirability, of such an animal-centred framework, examining the boundaries of its applicability as well as the benefits of its application. Finally, the paper puts forward a series of practical principles for conducting ACI research, which imply but also essentially exceed the welfare and ethics requirements of current regulatory frameworks.

**Keywords:** Animal-centred design; other-than-human animal participants; welfare-centred ethics; mediated consent; contingent consent; participant-centred ethics

## 1. Introduction

We live in a society where computing technology has become ubiquitous and interacting with computers no longer means using keyboard and mouse. Embedded in the fabric of our cities, workplaces, homes, vehicles, clothes and even bodies, ‘smart’ technologies now allow us to relate to the world around us, one another and even ourselves in unprecedented ways [29,54]. These achievements have been driven by what interaction designers call *user-centred design* in computing systems, which has shaped the field of Interaction Design (ID) [32].

Although ID as a discipline has so far focussed on humans as technology users, humans are not the only species to engage with interactive systems. Being directly or indirectly involved in every aspect of human life and inhabiting increasingly technologised environments, nonhuman animals (referred to as animals hereforth) too interact with technology, such as touch-screen operant chambers, robotic milking systems, or wearable telemetric devices. However, historically the development of animal technology has mostly been driven by disciplines other than Interaction Design and efforts to systematically develop user-centred approaches to the design of interactive technology for animals are still relatively very recent.

Consistent with this state of affairs, currently the involvement of animals in the development of technology intended for them still falls under the ethical frameworks that regulate their use according to national and international legislation (e.g. [14]). Within these frameworks animals are essentially viewed as research instruments, unable to understand and consent to procedures that may harm them, rather than research participants and design contributors with their own interests. The aim of current frameworks is to minimise any negative impact of the research on the welfare of the individual animals involved (typically through the implementation of the principles of replacement, reduction and refinement [39]); however, this minimisation is subordinated to specific scientific interests and to the integrity of the procedures required to serve those interests, provided that the interests in question are deemed of sufficient societal

significance. This approach is essentially different from that taken by ethical frameworks regulating the involvement of humans in research, including within ID [1], where the interests of the individual participant are prioritised over the interests of science. In other words, while ethics protocols that regulate research aiming to develop technology for humans are essentially user- and participant-centred, to date there is no legally established user- and participant-centred ethics protocol to regulate the involvement of animals in research aiming to develop technology intended for them.

In ID, *user-centred* means that an interactive technology is designed ‘around’ its intended users in order to best support them in their activities and daily lives. Here the term *user* is adopted in a broader sense and denotes anyone who interacts with a system, an *interactor* as referred to by North [30], whether the interaction is active and intentional [36], active and unintentional [24], passive and intentional [13] or passive and unintentional [26]. The established view in ID [32] is that, in order to best support users, interactive technology needs to be informed by their characteristics, as well as the characteristics of the activities for which it is used, or which it enables, and the environment in which said activities take place. It also needs to afford good *usability* (e.g., it should be safe to use, it should be easy to learn how to use, it should help users to perform a task efficiently) and *user-experience* (e.g., it should be motivating and stimulating to use). To achieve this, *requirements* about what a technology should do, and how, need to be elicited from those who have a stake in its development (primarily those who will use it), in order to inform alternative designs, which then need to be prototyped and evaluated, through an iterative process of incremental improvement. To this effect, ID researchers have long recognised the importance of involving prospective users in the design process and, since the advent of the Participatory Design movement [41], an increasing range of methodological approaches aiming to support user involvement have been developed or adopted in ID, allowing users to take the role of active research collaborators and design contributors.

If Animal-Computer Interaction (ACI) [27,28,34] aims expand the boundaries of Interaction Design by developing a user-centred approach to the design of technology intended for animals, then arguably ACI's ethical approach to research needs to be consistent with this fundamental aim, placing animals - as individuals and technology users, legitimate stakeholders and design contributors - and their interests at the centre of the design process. Such an ethical perspective is not only desirable on the grounds that animals have intrinsic value, as acknowledged by international legislation such as the European Constitution [47] and Directive on the use of animals in research [14]; an animal-centred ethical perspective is a methodological requirement [35] the fulfilment of which is necessary to foster the conditions for animal-centred design.

This paper is composed of two parts. Part 1 introduces ACI and the requirements that its proposed aims place on its research outcomes, processes and ethics. Having considered frameworks currently regulating the involvement of animals in research, the paper then makes the case that ACI's user-centred and participant-centred approach to interaction design and research requires a new, animal-centred framework. The paper discusses the relation of such a framework to current principles of best practice in animal research, highlighting the benefits of the proposed animal-centred framework for research participants, researchers and ACI as a discipline. Part 1 concludes by discussing the role of ACI research and ethics in the real world and the space it opens for animals as co-designers of shared futures. Part 2 then articulates a series of practical principles grounded in the proposed animal-centred framework.

## **PART 1**

### **2. ACI as an emerging discipline**

Animal technology has existed for a long time, to be found in research laboratories, in modern farms or in the field settings of conservation studies. For example, within conservation

research, animals have been wearing all kinds of tracking devices since the '60s [40]. Since more or less the same period, psychologists have been running behavioural experiments requiring animals to interact with the interfaces of operant conditioning chambers [12,43]. Touch-screen computers allowing great apes to learn and use lexigrams to communicate with human researchers have been around since the '80s [37,42]; while underwater keyboards for dolphins were initially prototyped in the early '90s [33]. Roughly at the same time, automatic robotic milking systems, which allow dairy cows to choose when to be milked, made their appearance [38].

For a long time, the development of these technologies has mostly been driven by disciplines other than Interaction Design (e.g. biology, psychology, engineering), as evidenced by the narratives and venues within which these contributions are reported, and - crucially - by the fact that the details of the design process are seldom published. With few exceptions [37], in these narratives design aspects relative to the devices themselves receive little attention compared, for example, to aspects of the research in which the devices are used; therefore, although user characteristics are taken into account, it is unclear to what extent the design process is informed by the requirements and the participation of the animal users.

At the turn of the millennium, however, there appears to be a change in the discourse. Computer scientists themselves start to take an interest in the design of interactive systems for animals and the design process itself begins to receive attention with direct reference to ID theories and frameworks [34]. Additionally, researchers attempt to evaluate not merely *usability* aspects (i.e. can the animal use this device at all and how easily can they use it?) but also potential *user experience* aspects (i.e. does the interaction with the device appear to be motivating and enjoyable for them?) of technology designed for animals [13,22,36]. Researchers also begin to propose methodological and theoretical frameworks to better understand, study and explain animal interactions with technology [26,51,52]. In an ACI



Manifesto, Mancini [28] called for a concerted effort towards the systematic development of ACI as a discipline around specific aims. The ethics framework proposed in this paper assumes these aims, which are therefore reported here in full:

1) *Understanding the interaction between animals and computing technology* within the contexts in which animals habitually live, are active, and socialize with members of their own or other species, including humans. Contexts, activities, and relationships will differ considerably between species, and between free living, companion, working, farm, or laboratory animals. In each case, the interplay between animal, technology, and contextual elements is of interest to the ACI researcher.

2) *Informing the development of interactive technology* to:

i) **Improve** animals' life quality or expectancy by facilitating the fulfilment of their physiological and psychological needs. Technology that encouraged healthy habits in animals or allowed them to modify their housing conditions at leisure might be consistent with this aim; similarly, technology that contributed to the refinement of animal farming or research procedures reducing their potential harm to the individuals involved might be consistent with this aim.

ii) **Support** animals in their activities and legal functions in which they are involved, by minimizing any negative effects and maximizing any positive effects of those functions on the animals' life expectancy and quality. Technology that gave farm animals control over the processes in which they are involved, produced only negligible side effects on the animals involved in conservation studies, or made it easier for working animals to perform and communicate might be consistent with this aim.

iii) **Foster** interspecies relationships (e.g. between humans and other animals) by enabling communication and promoting understanding between the two. Technology that allowed

animals to play with their humans, or that enabled guardians, carers and researchers to understand and respond to the interests and needs of their animals, or that brought animal perspectives into the assessment and development of human-animal relations might be consistent with this aim.

3) *Developing user-centred approaches to the design of technology intended for animals*, informed by the best available knowledge of animals' needs and preferences, to allow them to participate in the design process. Consistent with this, ACI appropriately regards animal users as legitimate stakeholders and design contributors throughout all the phases of the design process and beyond.

### 3. Design, methodology and ethical implications in ACI

Taking a *user-centred* approach to interaction design has implications on multiple levels. Firstly, it has implications for the features to be embedded in the design of an interactive product, which need to be informed by the user's characteristics and requirements, as well as those of their activities and of the environments in which they operate. These may include systems whose interfaces afford species-specific interaction [20,31,34] or systems that are seamlessly integrated in learning and working processes already familiar to the animals involved [24,36]; as well as conceptualisations of appropriate forms of interaction [49].

Secondly, user-centred design has implications for the characteristics of the methodological approaches employed during the research and design process, which need to enable users to express their requirements through appropriate forms of participation according to their characteristics; thus user-centred design is also *participant-centred* design. To varying degrees, many ID methodologies (e.g., questionnaires, interviews) rely on verbal communication or on the conceptualizations that natural language underpins, which makes their application to designing with animals problematic. Therefore, ACI researchers are working to adapt

participatory methodologies typically used in ID or other relevant disciplines. These may include multispecies ethnography [26] or ethology [3] to understand interactions in context and elicit design requirements [25], rapid prototyping to develop and test a design [36] or preference testing to evaluate user experience [22]; as well as conceptualisations of different levels of participation [18].

Thirdly, user-centred design has implications for the characteristics of the ethical perspective adopted by researchers and designers; this needs to foster the conditions for appropriate forms of engagement with users and enable their autonomous involvement in the design process as legitimate stakeholders and design contributors. But which criteria would an ACI research ethics need to meet in order to best support ACI's participatory practices? Mancini's ACI Manifesto [28] proposed five ethical principles, which aimed to foster researchers' respect and care for the welfare, interests and autonomy of the animals taking part in ACI research. However, such principles were not explicitly grounded in a wider ethical perspective, so their articulation appeared arbitrary, albeit sensible. More recently, Väättäjä and Pesonen [50] highlighted important concerns when carrying out HCI studies with animals and derived a set of ethics guidelines for designing, executing and reporting on such studies, based on their review of thirteen existing animal ethics sources. This was the first synthesis of existing regulatory frameworks directly relevant to ACI research and, as such, represented an important step forward in the development of an animal-centred ethics in interaction design. However, this paper makes the case that, from a user-centred perspective, existing regulatory frameworks informing animal research present essential limitations; further, the paper attempts to move beyond these limitations, articulating an animal-centred ethics that is more consistent with a user- and participant-centred perspective.

#### 4. Animal ethics in current legislation and protocols

European legislation, internationally, and British legislation, nationally, establish among the highest welfare standards for the involvement of animals in research; these standards are in turn reflected in the ethics guidelines of various disciplines and research funding bodies in Britain, with comparable examples in other countries. Precisely because they establish such comparatively high standards, European and British legislation provide a useful benchmark against which to examine the limitations of existing regulatory frameworks from a user- and participant-centred perspective. Such limitations will arguably be more significant in regulatory frameworks that contemplate lower welfare standards. On the other hand, since the framework proposed by this paper implies and exceeds the welfare standards established by current regulatory frameworks, it could legally be referred to and applied in any part of the world where higher welfare standards were not explicitly prohibited.

##### *4.1. International legislation: Europe*

The European Directive (2010/63/EU) “On the Protection of Animals Used for Scientific Purposes” [14] applies to scientific “procedures” which imply “any use, invasive or non-invasive, of an animal for experimental or other scientific purposes, with known or unknown outcome, or educational purposes, which may cause the animal a level of pain, suffering, distress or lasting harm equivalent to, or higher than, that caused by the introduction of a needle in accordance with good veterinary practice” (art. 3). The Directive recognises animal welfare as “a value of the Union enshrined in Article 13 of the Treaty on the Functioning of the European Union (TEFU) [47]” (par. 2). It also recognises that “new scientific knowledge is available in respect of factors influencing animal welfare as well as the capacity of animals to sense and express pain, suffering, distress and lasting harm” and that “it is therefore necessary

to improve the welfare of animals used in scientific procedures by raising the minimum standards for their protection in line with the latest scientific developments” (par. 6). On these grounds, “in addition to [non-human (art. 1)] vertebrates including cyclostomes, cephalopods” (par. 8 and art. 1) and “foetal forms of mammals in the last third of their development period” (par. 9 and art. 1) are protected under the Directive, due to their potential to experience pain, suffering, distress and lasting harm.

The obligation to treat animals “as sentient creatures” and restrict their use to “areas which may ultimately benefit human or animal health, or the environment” (par. 12 and art. 5) is motivated by the recognition that “animals have an intrinsic value which must be respected” and by the “ethical concerns of the general public as regards the use of animals in procedures” (par. 12). Thus animals who are closer to humans from an evolutionary perspective (e.g. non-human primates, particularly great apes) or from a social perspective (e.g. companion species such as cats and dogs) are warranted special consideration (par. 18, 21, 33). Where their welfare is not compromised by having undergone procedures, the directive indicates that “animals such as dogs and cats should be allowed to be rehomed in families as there is a high level of public concern as to the fate of such animals” (par. 26).

The Directive further prescribes that “the care and use of live animals for scientific purposes is governed by the internationally established principles of *replacement* [e.g. of animals with non-animal methods, of one species with a less sentient species], *reduction* [in the number of animals used, including the reuse of the same animals in more than one procedure (par.25)] and *refinement* [of procedures, in order to minimise their impact]” (par. 11 and art. 4) [39]. The development of alternative methods, which do not involve animals, is encouraged by the Directive (par. 10, 46, 47). Where animals are used, the Directive prescribes that “animal welfare considerations should be given the highest priority in the context of animal keeping, breeding and use” (par. 31) and that the killing of animals at the end of a procedure should be

carried out “by a competent person, using a method that is appropriate to the species” to minimise “pain, distress and suffering to the animal” (par. 15). The Directive furthermore prescribes that it is “essential, both on moral and scientific ground, to ensure that each use of an animal is carefully evaluated as to the scientific and educational validity, usefulness and relevance of the expected results of that use” and that “the likely harm to the animal should be balanced against the expected benefits of the project” (par. 39), where benefits could relate to human health, the health of other animals or the environment. The Directive details minimum requirements for the sourcing, accommodation and care of animals used in procedures to ensure acceptable welfare standards (section 1 of chapter IV and annex III). It also requires national animal ethical review bodies to assess research proposals and ensure compliance with legal welfare requirements, and establishes criteria for increasing transparency in the use of animals for research purposes (art. 26-27).

#### *4.2. National regulations: the United Kingdom*

In the United Kingdom, the Animal (Scientific Procedures) Act 1986 (ASPA) Amendment Regulations 2012 [5] differ from the Directive in relatively minor ways. For example, the definition of “regulated procedure” (section 4) and the purposes for which procedures are allowed (section 5) are the same. Similarly, protected animals are also vertebrates, although protection could be extended to invertebrates, should evidence of sentience emerge. There is the same strong emphasis on the implementation of the principles of replacement, reduction and refinement (section 5), and on care standards (e.g. section 14 and 17). Likewise, there is a provision for setting free or rehoming animals under specific conditions (section 18) and, when setting free or rehoming is not permitted, the killing of animals at the end of procedures is also tightly regulated (section 15). Procedures which are regulated under the ASPA and Amendment Regulations 2012 have to be licenced by the Secretary of State, following a cost-benefit analysis.

Research which involves animals but is not covered by the ASPA and Amendment Regulations 2012 might fall under other legislation. In particular, research involving British wildlife or studies in the countryside is covered by the Wildlife and Countryside Act 1981 [7]. The Act protects wild birds during mating and breeding season (section 1), and a selection of other species of wild animals all year round (section 9). The Act specifically prohibits the unauthorised “intentional killing, injuring or taking of the animals; the taking, damaging, destroying of or obstructing access to nests or places used for shelter or protection while in use, or the disturbance of animals occupying such places” (section 1). The Act also prohibits the unauthorised “taking or destroying of eggs; and possession or control of protected animals” (whether live or dead) and their sale (whether as a whole or parts). It additionally regulates the lawful killing of wild animals by prohibiting certain methods (section 5 and 11), and it prescribes minimum standards for the lawful keeping of captive birds, except poultry (section 8). As with procedures regulated by the ASPA and Amendment Regulations, all scientific procedures which entail prohibited activities also require a licence from the Secretary of State.

Research which does not require a Secretary of State’s licence still falls under the legislature of the Animal Welfare Act 2006 [6]. While the Act 2006 is not specifically intended to regulate research procedures, it provides an indication of a minimum standard of care to be observed for non-regulated practices. The Act protects domesticated and managed (section 2) non-human vertebrate animals (and possibly invertebrate animals, where scientific evidence has demonstrated their sentience) (section 1). Under the Act, no one is allowed to cause an animal to suffer “unnecessarily” (section 4). Here suffering is considered unnecessary unless: it cannot reasonably be avoided or reduced; it results from conduct which aims to implement a licence or code of practice issued under an enactment (e.g. a cull or regulated procedure); it results from conduct whose legitimate purpose is to benefit the animal or protect a person, property or other animal, and the conduct is proportionate to achieving its purpose by a reasonably competent and humane person. Additionally, under the Act those who own or are in charge of (and have

in their care) an animal are responsible for their welfare (section 3) and must take reasonable steps in all circumstances to ensure that the needs of the animal are met to the extent required by good practice. Such needs include: a suitable environment to live; a suitable diet; being able to exhibit normal behaviour patterns; being housed with, or apart from, other animals as appropriate; being protected from pain, suffering, injury and disease (section 9). However, “the destruction of an animal in an appropriate and humane manner” is excluded by the considerations the Act makes in relation to their suffering or to the fulfilment of their needs (section 4 and 9).

#### *4.3. Derived research ethics protocols and guidelines*

Research ethics protocols across research associations and funding bodies in turn reflect national regulations regarding the use of animals in research and animal welfare more generally. In the UK - in collaboration with the Biotechnology and Biological Sciences Research Council (BBSRC), the Department of Environment, Food and Rural Affairs (Defra), the Medical Research Council (MRC), the Natural Environment Research Council (NERC) and the Wellcome Trust - the National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3Rs) produced guidelines detailing researchers’ responsibilities in the use of animals in bioscience [10]. This is directly informed by the ASPA (and Amendment Regulations), as well as the Wildlife and Countryside Act and Animal Welfare Act, with emphasis on the implementation of the principles of replacement, reduction and refinement, the careful consideration of costs to animal welfare in relation to scientific benefits, and welfare standards regarding the sourcing, transportation, housing, husbandry, care and killing of the animals being used. Similar requirements for the use of animals in research can be found in the ethics guidelines of national and international scientific associations, such as the British Psychological Society [11], the Association for the Study of Animal Behaviour [2], or the International Society for Applied Ethology [19]. Additionally, these guidelines invite more



extensive protections for the animals involved, for example, by considering both vertebrates and invertebrates on the grounds of their potential sentience, and by encouraging researchers to design procedures that entail non-aversive stimuli and offer the animal the opportunity to withdraw from a procedure, compatibly with the aims of the research.

## **5. Limitations of existing frameworks**

Although these protocols and guidelines represent the state-of-the-art with regards to the protection of animals involved in research, some of their underlying assumptions are inconsistent with ACT's proposed user- and participant-centred perspective. As discussed, in existing legal frameworks only species who possess specific physiological characteristics (e.g. a spinal cord) or specific psychological characteristics (e.g. sentience) are protected under those frameworks. This has the implication that, for animals who do not possess those characteristics or in whom those characteristics are more difficult to measure, the grounds for protection are weaker or lacking altogether. Moreover, independently of their physiological and psychological characteristics, animals are not protected solely on the grounds of their intrinsic value but also on the grounds of their societal value, which means that species who happen to be regarded as companions rather than food (e.g. dogs vs pigs in Western cultures) are granted higher protection regardless of their welfare requirements. Overall, the strong focus on category-based distinctions (e.g. dogs vs mice, stray vs bred) to be found in these frameworks does not account for individual differences (and related requirements) beyond such categorisations.

Animals involved in research are effectively regarded as instruments in the experimental apparatus, albeit instruments who need to be treated with careful consideration, rather than as participants in the research process. In the regulations, protocols and guidelines discussed above, such a perspective is signalled in a number of ways. For one thing, regulated research does not have to be relevant to the animals involved (e.g. an animal might be used as a model

for investigating a disease or cognition in, or test drugs for, a different species). Furthermore, although the use of animals in research procedures has to be approved by a competent authority following a cost-benefit analysis, any envisaged benefits need not be to the advantage of the individuals involved or even to members of their species, and any costs to the individuals involved may be deemed acceptable if the expected benefits to society are deemed to warrant such costs. From this perspective, while all regulations, protocols and guidelines prescribe minimisation of any suffering and harm, such minimisation is subordinated to the aims of the research (e.g. the avoidance of death as the end point of a procedure or the use of anaesthesia for a procedure that could cause the animal to suffer are recommended, but that is provided compatibility with the purpose of the procedure). Along the same lines, although some protocols consider allowing the animals involved the possibility to withdraw from a procedure where possible, this possibility is again subordinated to the aims of the research; mostly, existing frameworks make no explicit provision for enabling animals to consent, or dissent, to their involvement. Finally, although researchers are encouraged to make alternative arrangements wherever possible, the killing of animals at the end of procedures is generally permissible and still treated as a matter of course provided the method of killing is deemed humane; this is the case not only for humane reasons, when the welfare of animals used in a procedure is irretrievably compromised as a result, but also for logistical reasons, when at the end of a procedure the animals involved are no longer needed and therefore become surplus to requirement.

Within this landscape, the principles of replacement, reduction and refinement are generally advocated as best practice, in order to achieve the best possible compromise between animal welfare requirements and research interests. However, while aiming to limit the impact of research practices on the individuals involved, such principles and the mode of their implementation in fact reflect a lack of individual perspective. For example, the principle of replacement reinforces the assumption that animals are substitutable components of an

experimental set-up. The fact that the reuse of an animal, albeit strongly regulated, is considered a viable solution for implementing the principle of reduction is also symptomatic of a perspective in which animals and their subjective experience (whatever this might be) are regarded as the abstract-able, add-able, subtract-able, interchange-able quantities of an experimental equation.

Of course, this is not to say that the principles of replacement, reduction and refinement bear no relevance to ACI research, nor that in practice ACI research is always completely different from any other research involving animals, nor that cost-benefit considerations or procedural integrity are not important in ACI research. Rather it is a matter of perspective: arguably, in user- and participant-centred research, considerations of cost-benefit, procedural integrity, consent and engagement should pivot around the characteristics and requirements of the animals involved, which implies a change of focus with respect to the regulations, protocols and guidelines discussed above. This does not mean that said regulations, protocols and guidelines are no longer important, but simply that for the purposes of ACI research they are inadequate, because they assume a perspective whereby the characteristics and requirements of the animals involved are not pivotal; in other words, current regulations, protocols and guidelines are not animal-centred. On the other hand, a reframing of animal research from an animal-centred perspective could not only better support ACI researchers and practitioners; it could also better support researcher and practitioners who work with animals in other fields and whose research would benefit from being consistent with such a perspective (e.g., certain ethological studies).

## **6. Ethical implications of user- and participant-centred design for and with animals**

This paper argues that, in order to be consistent with a user- and participant-centred perspective, ACI's ethical approach to research needs to be informed by different criteria. Firstly, it is not the animal characteristics that provide grounds for their treatment but rather

their *role* as users and research participants. Thus, giving all animals involved in ACI research equal protection and care (according to their individual needs) is the most appropriate way to ensure that their requirements as users can emerge during the process and can therefore be designed for with their active participation. On the other hand, precisely because user characteristics are so central to the design process, animals cannot be viewed as the substitutable components of an experimental set-up. Therefore, it is only appropriate to involve an animal in research if this is directly relevant to them. Furthermore, Vääätäjä proposes animal welfare as a specific design goal [49]; indeed, if one recognises that maintaining good welfare at all times is an important individual requirement, in order to be consistent with user- and participant-centred design ACI research needs to be compatible with the welfare of both end users and research participants. As discussed above, protecting the welfare of animals used in research is the aim of related institutional directives, protocols and guidelines. But what are the specific implications of ACI's animal-centred perspective in this regard?

### 6.1. A welfare-centred ethics

What constitutes good welfare for animals is the object of on-going research [15,16], some notions of animal welfare assuming more than others that animals are capable of conscious and sentient experience. Because it bypasses the issue of consciousness and sentience, and is therefore relevant to all animals, the notion of welfare proposed by Stamp Dawkins [44,45,46] is particularly useful here. For Stamp Dawkins animal welfare presupposes the fulfilment of two fundamental conditions: that an animal *is healthy* and that they *have what they want*. The author's rationale is that animals have evolved adaptations for coping with environmental conditions (e.g. a thick coat), for exploiting available resources (e.g. specific hunting techniques or a specialised digestive system) and for recovering from injury (e.g. mounting an immune response), in order to maintain good health thus maximising their chances of survival and reproduction. However, Stamp Dawkins points out, animals have also evolved adaptations

for preventing the occurrence of conditions that could compromise their survival in the first place, adaptations which result in the animals wanting certain things: for example, wanting to search for prey that might be hiding in the ground, or wanting to burrow to hide from potential predators. For Stamp Dawkins, the animal being healthy and having what they want are interdependent conditions or, as interaction designers would say, requirements (e.g. a captive animal whose exploratory drive is constantly frustrated may develop harmful compulsive behaviours), which need to be satisfied at the same time (e.g. giving an animal free access to food needs to be compatible with maintaining their optimal weight). If only one of the two conditions is satisfied, welfare is compromised.

It follows that ACI research should never threaten the health of the animals involved and never deny them what they want, unless denying or limiting what they want is necessary to preserve their health. More specifically, the welfare requirement that an *animal is healthy* means that ACI research should never entail practices or procedures which interfere with the evolutionary adaptations that support the animal's health (e.g. through genetic manipulations), or threaten the animal's health by compromising their physiological or psychological integrity (e.g. through invasive, aversive or otherwise injurious manipulations). On the other hand, the welfare requirement that an *animal has what they want* means that ACI research practices or procedures should never prevent an animal from expressing spontaneous behaviour (e.g. through restriction or constriction), or entail the confinement of an animal within settings which are not those for which they have evolved (e.g. through caging). The only cases in which ACI research would be connected to (without requiring or instigating) such practices or procedures would be if these already occurred in the context where the research took place (e.g. if the research took place on a farm where confinement was part of husbandry practices, or if the research took place in a veterinary clinic where movement restriction was part of therapeutic procedures).

Stamp Dawkins [44] notes how generally the death of an animal is not in itself considered a welfare issue on the grounds that a dead animal cannot suffer, from which would follow that the killing of an animal upon completion of a research procedure, an accepted practice by current legislation, does not impact on their welfare unless it causes the animal to suffer in the process. However, such a position seems to be at odds with the very evolutionary definition of animal welfare. If an animal has evolved certain adaptations precisely because these allow them to stay alive, and if violations to the animal's adaptations impact on their welfare, then interventions that lead to the animal's death arguably pose a welfare issue on the grounds that such interventions are incompatible with the very *function* that has allowed those adaptations to evolve (if not with their very *purpose*). Bekoff [4] argues how the struggle of an animal who is under attack indicates that his life matters to him; this point is arguably valid whether the animal is or not aware of the attack, or even whether he is or not aware of being alive. As Stamp Dawkins [39] points out, struggling (e.g. to break free from confinement) is an evolutionary adaptation ultimately aimed at keeping the animal alive and well. Whether the threat to an animal's life is delivered *overtly* in a form that the animal is able to recognise as a threat (e.g. strangulation) and thus respond to (e.g. struggling), or *covertly* in a form that the animal is unable to recognise (e.g. lethal injection during sedation) and thus respond to (e.g. hiding), the fact remains that such a threat opposes the very function of the animal's life-preserving adaptations. In this respect, it could be argued that killing can never be compatible with animal welfare, except when the very mechanisms whose function is to keep the animal alive and well are so irretrievably compromised (e.g. because of illness) that there is no hope for the animal's health and contentment to be restored to balance. Thus, on welfare grounds, the killing of participating animals at the end of research procedures is incompatible with ACI's animal-centred perspective.

Instead, consistent with Stamp Dawkins' definition of welfare [44], researchers should always endeavour to respect the animal's identity and safeguard their integrity, both physiological and

psychological, at all times. This means that researchers should work in contexts that are habitual for and thus familiar to the animal; they should endeavour to be as unobtrusive and undistruptive of the animal's daily life patterns and routines as possible; they should give the animal space for expression and control over the research process; and they should use only forms of interaction which are respectful of and responsive to the animal's needs and wants at all times. In animal-centred research, the interests of individual participants should "prevail over the interests of science and society, where there is conflict" [9] and any potential risks to individual participants should outweigh any potential benefits to others. Therefore any cost-benefit analysis of the research should be carried out from the perspective of what, at the best of the researchers' knowledge, are the animal's best interests. In user-centred design this is both an ethical imperative, as recognised by ethics frameworks regulating the involvement of humans in HCI research [1], and a methodological necessity, as argued by Ritvo and Allison in their discussion of research methodologies applicable to ACI [35]. But how can researchers ensure that, in the case of animals, the interests and requirements of users and research participants are appropriately represented and thus prioritised?

## *6.2. The issue of consent*

Existing frameworks motivate the need to minimise the impact of research procedures on the welfare of the animals involved, on the grounds that animals are capable of suffering whilst being incapable of consenting. Consenting implies the ability to comprehend the immediate and wider implications of one's involvement [15], but of course interspecies cognitive differences and communication barriers make conveying the welfare implications of a research procedure to other animals very challenging if not practically impossible. Nevertheless, consent arguably marks an important difference between subjection and participation, thus in user-centred research the animals' consent needs to somehow be sought.

Of course, one approach to the issue is seeking consent *for* animals via *mediators* who are capable of comprehending the implications of the research in relation to the animals' welfare requirements, and who have the legal authority to consent on their behalf. To ensure that consent is provided from a user- and participant-centred perspective, such agents should also have a vested interest in prioritising the welfare of the animals concerned. Furthermore, since in user-centred research participants are not merely representatives of a category or substitutable components of an experimental apparatus but individuals, consent should be sought on an individual basis. In this regard, Mancini et al. [26] highlighted the complementary role of the animals' daily carers, on the one hand, and animal welfare experts, on the other hand: the former hold critical contextual knowledge about an individual's characteristic patterns and circumstances, while the latter hold essential expertise to assess those characteristic patterns and circumstances in relation to established animal welfare knowledge [50]. Thus, overall *mediated consent* should imply the following: 1) the capacity to comprehend the immediate and wider welfare implications of a procedure, 2) a vested interest in prioritising the welfare of individual animals 3) familiarity with the individual's characteristic patterns and circumstances, 4) animal welfare expertise relevant to the individual, 5) the legal authority to consent on behalf of the animal. Whether all or part of these competences are distributed across different individuals (e.g. the animal's human companion who is also their legal guardian and an independent animal welfare expert) or are found within one individual (e.g. if the human companion and legal guardian is also an animal welfare expert), they should all be represented in the consenting process. Additionally, an independent authority, such as the animal welfare review bodies envisaged by the European Directive, should ensure that the above conditions are met in compliance with ACI's research ethics framework as well as existing legislation.

On the other hand, voluntary engagement is a fundamental aspect of consent [15]; however, clearly it would not be realistic to assume that mediators know what the animal they represent



wants in specific contingencies. Thus mediation does not eliminate the need to obtain some form of *contingent consent* from the animals themselves. While animals might not be able to assess the welfare or wider implications of a procedure, they are nevertheless able to respond to specific conditions [44], provided they are afforded the freedom to make relevant choices, including the choice not to engage or withdraw altogether. Ritvo and Allison [35] propose that participant-controlled procedures are best suited to enable animals' preferences to emerge in ACI research; these may entail dichotomous-choice protocols, whereby participants choose whether or not to be exposed to a stimulus, or multi-stimulus protocols, whereby participants can choose between different stimuli as well as the length of stimulus exposure. If a participant is enabled to choose the pace and modality of their engagement with, or withdrawal from, the research process at any time, then their response can provide *a measure* of their consent to engaging with a specific research set-up. Of course, any contextual variations during a procedure might affect the participant's assessment of the situation and thus their amenability to participate, so whether participants are able to assess the situation is an important consideration.

Luger and Rodden [23] argue that, as ubiquitous computing systems become more complex and seamless, and support an increasing range of daily activities, the data that drives their functionalities is increasingly abstracted from its original context; this makes it impossible for (human) users to understand the implications of their interactions with such systems and thus provide informed consent to the use of data they divulge during the course of those interactions. In this respect, the authors emphasise the dynamic nature of consent and the importance of enabling effective withdrawal at any time; they also stress the importance of giving users visibility over data flows within systems and the ability to easily interrogate the system to evaluate the cost-benefit trade-offs of engaging or withdrawing. In a more concrete sense, these are similarly useful considerations when designing ACI research procedures. Thus, overall *contingent consent* should imply the following: 1) procedural set-ups that enable the

animal to assess the situation as much as possible (e.g. allowing the animal to freely explore their surroundings or any research equipment as appropriate prior to starting a procedure, and at regular intervals during the procedure), 2) opportunities for the animal to make relevant choices between alternative forms of engagement (e.g. between different forms of input or output in an interface; between reward mechanisms based on food or play), 3) the possibility for the animal to effectively withdraw or withhold engagement (e.g. plenty of escape routes or comfortable rest areas as appropriate). Importantly, in order to monitor levels of consent over time, researchers should be able to continually and expertly monitor variations in the participant's response to a procedure against their welfare requirements, as highlighted by Vääätäjä and Pesonen [50], and dynamically and promptly make any appropriate adjustments, including suspending a procedure.

Researchers who work with non-competent or non-linguistic humans [8,9] are well familiar with notions of mediated and contingent consent, its dynamic and transient nature (e.g. consent as a process rather than as a one-off occurrence [9]), and the critical importance of monitoring and responding to signs of dissent (e.g. a young child becoming upset [9]). They are also aware of the necessary complementarity of the two forms of consent [8,9], whereby those who can see the wider implications of a participant's involvement lend their insight in the participant's best interest, while the participant themselves is the only one who can assess the contingent, directly experiential implications. Consistent with the implications of user- and participant-centred research, the very ethical perspective underpinning these notions is just as relevant here. But how does such a perspective relate to the universally advocated principles of replacement, reduction and refinement [37]?

## **7. ACI's research ethics and the 3Rs**

As discussed earlier, in bioscience the implementation of the principles of refinement, reduction and replacement, commonly known as the 3Rs [39], has become an important

requirement to address the ethical conflict between the fact that animals cannot consent to their involvement in potentially harmful research procedures and the fact that human society considers their use in such procedures necessary to achieve a greater good. Indeed, ACI's user-centred and participant-centred research has the potential to significantly contribute to the implementation of the 3Rs in bioscience: through ACI's research outcomes, which could produce knowledge and technology enabling the refinement of future research procedures; and through ACI's methodological approach, which pushes researchers to develop refined procedures in the first place on ethical and scientific grounds.

On the other hand, for the reasons discussed above, the 3Rs reflect an ethics perspective that, albeit animal-welfare-minded, is not animal-welfare-centred, as demonstrated by the fact that research that does cause harm to the animals involved can still be carried out under the auspices of the 3Rs, provided the expected outcomes are deemed important enough for society. Therefore, the relation of ACI research practices to the 3Rs is somewhat more complex than it might be in other bioscience domains. Like any other research involving animals, ACI research should endeavour to *refine* its procedures for both ethical and scientific reasons. This includes the need to protect animals from poor research designs and meaningless procedures, where the meaning of a procedure should be primarily assessed with respect to the interests of the animals involved. Although procedures that imply more than negligible risks for the participants are in principle incompatible with ACI's aims in the first place, where non-risky procedures are deemed meaningful (i.e. relevant and potentially beneficial for the animals involved), refinement can ensure that even unforeseeable risks are reduced while increasing the viability of any data obtained and the success of any design. Of course, refinement pertains both to the design and execution of research procedures, and to their proper and accurate documentation and publication, so that procedures do not need to be unnecessarily repeated and findings can be reliably built upon by the research community [50].

Similarly to other research involving animals, ACI research should consider the appropriateness of reducing the number of individual animals involved. However, when deciding on numbers, consideration should be given to the fact that statistical power (the main criterion commonly used for reduction) is not the only important factor. In ACI research, animals' involvement is valuable not only for their general characteristics as representatives of a category, but also for their individual characteristics [36], which can produce important insights. This aspect should be considered in light of the fundamental conditions that the interests of individual participants are always prioritised, and their involvement is fully justified and authorised by a competent scientific and ethical review body.

Similarly to other research involving animals, ACI research should aim to replace them whenever possible. However, as discussed above, in ACI animals should not be seen as the substitutable components of an experimental set-up. Precisely because animals cannot provide informed consent to taking part in research procedures, it is important that researchers work with individual animals only if the intent is to advance knowledge or develop technology that is directly beneficial or otherwise relevant to those individuals. Therefore, replacing one species with another species (even a less sentient one) is not appropriate, unless the individuals of the species involved as a replacement have themselves a stake in the research process. For example, if researchers were to work with mice to develop an interface designed to help assistance dogs carry out certain tasks around the house of their assisted humans, they would do a disservice both to the mice (who would be involved in a process in which they have no stake) and to the dogs (who would find themselves having to use a product that was not designed for them). Indeed, researchers ought to be able to work not just with any dogs, but specifically with the end users of the interface being designed, that is the assistance dogs for whom the interface was being developed (who do have a stake in the process and who, as individuals, would directly benefit from the research).

However, at least for parts of the research or development process, replacing the target species with methods that do not involve animals or that involve consenting competent humans is desirable. In ID, research procedures do not necessarily involve end users at all times: for limited parts of the development process, researchers apply heuristics, execute technical tests or themselves take part in preliminary testing to ensure that a prototype is the best it can be before it is proposed to the users for evaluation [36]. Similarly, in ACI, researchers could apply heuristics, execute technical tests or involve consenting competent humans in preliminary testing before evaluating a prototype with their target users. Indeed, research methodologies could be developed to allow human participants to take part in requirements elicitation or preliminary evaluation activities on behalf of animal users. However, it is important to note that researchers cannot expect to altogether replace their animal users with humans or machines and still produce technology that is user-centred, because their target users are neither humans nor machines. Users have unique characteristics, interests and requirements that researchers need to understand and design for, to do which they need their users to be part of the process at least at key points if not throughout. As with reduction, the issue of replacement should be considered in light of the fundamental conditions that the interests of individual participants are always prioritised, and their involvement is fully justified and authorised by a competent scientific and ethical review body.

## **8. Benefits of ACI's research ethics protocol**

As we have seen, while a wealth of frameworks exist which cover the involvement of animals in research, the ethical assumptions informing such frameworks fall short of the standards required for consistency with ACI's user- and participant-centred perspective. Arguably, an animal-welfare-centred framework which is more consistent with such a perspective, and which can appropriately inform ACI research practices, can therefore better support ACI researchers in their work and the development of ACI as a discipline, while protecting the

animals participating in the research. Such support might equally relate to the design, execution and evaluation of research procedures [47] (research processes), to the conception, development and deployment of interactive technologies (research outcomes), or to the public demonstration of both research processes and outcomes during peer or public engagement activities. Arguably, at a time when ACI research projects are increasing in numbers and scope worldwide, and are making an appearance at scientific and other public events (e.g. conferences, workshops, exhibitions), an animal-centred ethics framework can not only serve as a benchmark for ACI research practices involving animals either in the lab or in the wild, but also more generally as a vehicle for fostering a research culture of mindfulness and respect of the needs and requirements of (human and other-than-human) animal research participants.

On the other hand, while primarily aiming to protect animal participants, the ACI research ethics framework proposed here also aims to protect the researchers who work with them. The use of animals in research can elicit strong responses in favour (e.g. [48]) or against (e.g. [53]) as to its ethical acceptability. Indeed, the ethical dilemma posed by animal research is at the base of on-going efforts to replace, reduce and refine animal use in scientific procedures (e.g. [14]). Consistent with such a dilemma, it is likely that the position of ACI researchers will vary across the spectrum and that some ACI researchers will be uncomfortable with the idea of using, or being perceived as using, animals in scientific procedures that are potentially harmful to or demeaning of them. For these researchers it may be more agreeable to engage in ACI research if their activities can be explicitly referred to an ethics framework that grants the highest degree of protection to the animals they wish to work with. Such researchers are entitled to the reassurance that may derive from the awareness that they are operating under the banner of such a framework, which in turn may enable them to work more effectively.

Similarly, the proposed ACI research ethics framework aims to reassure and protect the general public, by creating the conditions for ACI research to be conducted with full transparency, thus

remaining open to public scrutiny, consistent with recent regulatory trends, but not necessarily current practice in other domains [14]. On the other hand, enabling ACI researchers to discuss their work openly without fear of repercussions is important to ensure that members of the public have no reason to speculate and draw misinformed conclusions about such research. Exposure of ACI research is additionally important to the fulfilment of ACI aims, which include fostering better relationships between humans and animals through promoting better understanding between parties. In this respect, public engagement with ACI research (e.g. by enabling members of the public to participate in research activities with their companion animals) has a key role to play.

## **9. ACI research and ethics in the real world**

Since ACI's animal-welfare-centred ethics differs in perspective from the perspective of existing ethical frameworks regulating the involvement of animals in research and other human practices (e.g. farming), one might question whether it is appropriate for ACI researchers to ever engage with systems whose very functioning is only possible because animal welfare is not the central value. The way in which ACI researchers negotiate the ethical boundaries between their research and the systems in which their research might take place (e.g. farms, laboratories, zoos) is likely to depend on their knowledge and value system. As an extreme example, some ACI researchers might be willing to design digitally enhanced slaughterhouses to reduce farm animals' suffering at the time of slaughter, while others might not be willing to design technology whose very purpose is to kill animals.

Similarly, there are ethical boundaries to be negotiated between the interests of the animals involved in ACI research and the interests of anyone who might be affected by or as a result of the research. While from a user- and participant-centred perspective the interests of the animals involved in the research are of pivotal importance, the interests of other stakeholders also need to be considered. For example, an ambient interactive system that enabled tigers to find and

catch deer more efficiently as a way of supporting the survival of the species in the wild would raise a range of ethical issues, as it would cause suffering and death to other animals and potentially alter a delicate balance in the ecosystem. Some ACI researchers might feel that this would be justified to help an endangered species, while some would reject the idea as unfair and even cruel to deer.

The future of farming and conservation will likely depend on the evolution of the socio-economic (and value) systems in which these practices take place, and whether ACI research can influence such evolution will likely depend on how ACI researchers choose to engage with those socio-economic systems. Uncomfortable as it might be for some, arguably it is important that ACI researchers are willing to engage with those systems, for that is the most direct way in which ACI can effect change in the real world. Broadly speaking, ACI researchers could effect change by developing animal-centred technology to improve the lives of individual animals whatever their situation, by exploring animal-centred research methodologies which enable animals to influence the design of the environments in which they find themselves, and by promoting through their research practices and outcomes an animal-centred ethics which could contribute to changing the way animals are regarded and related to in human society. To this effect, if they do choose to engage, it will arguably be more productive if ACI researchers engage constructively with the processes taking place within existing socio-economic systems as well as the ethical frameworks that regulate those systems' functions. At the same time, it remains the responsibility of ACI researchers to operate within the boundaries of an animal-welfare-centred ethics, both when designing technology and when designing research, and in general with regards to their attitude and behaviour towards the animals they work with.

However, even if ACI research remained consistent with an animal-welfare-centred ethics, it could be argued that ACI research itself is just as ethically problematic as any other research involving animals on the grounds that, independently of the nature of any research practice,



animals cannot give informed consent to their involvement; thus involving them inevitably compromises their autonomy and reduces them to instruments within processes over which they have no real control. Although fundamental, this issue should not be abstracted from the contexts that already define the relationships between humans and other species. Animals do not necessarily consent to those relationships (e.g., cows to being farmed, dogs to assisting, horses to racing), thus it could be argued that their autonomy within those relationships is already compromised. But, it is precisely within the contextual (and ethical) limitations of such human-animal relationships that ACI research situates itself, providing opportunities for the expression and fulfilment of animals' autonomy as a starting point for designing technology that can better support their activities, improve their lives, increase our understanding of them and raise their standing in human society. Providing animals with technology that enables them to better control the functions in which they are already involved affords them the possibility to exert a measure of autonomy, albeit within contextual limitations. As their autonomy is progressively supported by animal-centred technology, cultural and ethical assumptions might be questioned, and a space might be pushed open where animals are enabled to more significantly participate in co-designing shared environments with humans [27]. In order for technology to be animal-centred, though, animals need to be part of the research processes that lead to the development of such technology. Giving animals the opportunity to participate in, and thus inform, the processes in which they have a stake is one way of empowering them, albeit limitedly. Involving animals as participants in processes in which they have a stake is not the same as using animals as instruments in processes in which they have no stake. Arguably, whether autonomy is denied or promoted, whether animals are used or users, subjects or participants, is not necessarily a choice researchers make by either involving animals in research or leaving them out of it. Rather it is a choice researchers make within the context of specific research practices, throughout concrete research processes, in the way they regard and

relate to the animals they work with, from the moment they set their research goals to the moment they write their final research reports [50].

## 10. Conclusions

Our interactions with the increasingly technologized environments we inhabit have over time been enabled by ever thickening layers of technological complexity. For many decades we have been driving cars, most of us without knowing how engines work; more recently we have learnt to move and socialise within the virtual realities which exist in our computers, most of us blissfully oblivious to the stratifications of code powering these machines; as we go about our daily business, our spontaneous gestures and movements within cybertectural spaces trigger all kinds of environmental changes without us even realising; our activity patterns are recorded by the many ubiquitous computing devices we interact with during most of our day, and our data put to uses we are not aware of. With the inner workings of everyday technology obscured behind seamless interfaces, our ability to make sense of what technology does beneath the surface of our immediate experience can be severely limited; and so can our understanding of the implications of our increasingly implicit technologically-mediated interactions [21]. In this respect, the position of a dog who interacts with a computing interface with a limited understanding of the situation beyond ‘their own here and now’ is not dissimilar to that of a human seamlessly interacting with much contemporary computing technology. Indeed, with all its complexities, technology is beginning to blur the boundaries between human and animal agency, just as it is blurring the boundaries between users and interactors [30]. Within this landscape, ACI has the potential to significantly contribute to the re-assessment of anthropocentric interpretations of concepts such as ‘use’ and ‘participation’, both in interaction design as a discipline and in the design of future smart environments.

So far the design of technological interactions has taken place in a socio-economic anthropocentric space, and has been driven by anthropocentric agendas [27]. But this does not

mean that, afforded adequate access, animals would not be able to join the design table. Unlike human researchers, animal participants may not be able to comprehend the wider implications of the research processes they are involved in; and they may not share with designers the same understanding of the technological interactions they are exposed to. Nevertheless, animals are able to interact with and make sense of their immediate surroundings, at least in relation to the needs and wants evolution has endowed them with, and whatever they have learnt to do in order to fulfil those. If ACI is to afford animals the role of design contributors, it is essential that ACI researchers enable animals' needs and wants to emerge during the design process, and prioritise them over other extrinsic interests. As we have seen, existing regulatory frameworks for the involvement of animals in research essentially regard them as instruments in an experimental apparatus, while recognising their need for protection on the grounds of their inability to consent to their involvement and the potential harm that can ensue. In these frameworks such protection depends on criteria that don't necessarily reflect the needs and wants of the individuals involved and that ultimately prioritise other interests. Such anthropocentric ethical perspective may be appropriate for human-centred research, but if ACI is to truly lead to animal-centred research, its ethical perspective needs to go beyond existing regulatory frameworks and guidelines. ACI needs an animal-centred ethics that can foster a culture of respect and sensitivity towards the requirements of animal research participants within the research community; an ethics that can inform the appropriate methodological conditions for enabling animals to express their requirements, thus allowing their requirements to shape the design process and mould the building blocks of a multispecies society.

## **PART 2**

### **Ethical principles for Animal-Centred Research**

In ACI's animal-centred research the interests of 'nonhuman animal' (hereafter 'animal') participants (as those of human participants where applicable) should always prevail over those of science and society, where there is conflict [9]. At all times researchers and research procedures should protect the welfare (health, wants and life), and respect the autonomy and dignity of animal (and human) participants. This fundamental perspective can be articulated through the following principles.

### ***1. Respecting and caring for every participant without discrimination***

- Researchers should acknowledge and respect the individual characteristics of every animal participating in the research regardless of categorisation such as species, sex or provenance; and they should treat all research participants (humans or animals) as individuals equally deserving of consideration and care according to their welfare requirements.

### ***2. Garnering participants' mediated and contingent consent***

- Researchers should obtain free and voluntary informed consent to the involvement of animal (as well as human) participants in research activities from those who are legally responsible for them and involved in their day to day care (as is the case with non-competent children; when doing research with competent adults and children, consent should be obtained from the participants themselves). For companion animals these might be their human companions; for animals living in shelters and zoos these might be the facilities' managers and the individuals' carers. Obtaining this form of *mediated consent* should be seen as a continuing process, not just as a one-off occurrence [8,9], and legal guardians should always be informed that they can withdraw participants from the research at any time without needing to provide an explanation.
- Researchers should garner the voluntary consent of the animals to their involvement in research activities and obtaining this form of *contingent consent* should be seen as a

continuing process, not just as a one-off occurrence [8,9]. To this end, research set-ups should be designed to facilitate participants' assessment of their immediate situation throughout procedures. Procedural conditions should always, and without exception, afford animal (and human) participants the possibility to choose whether to engage with the research, as well as the possibility to withdraw at any time, either temporarily or permanently, from the research. If participants (animals or non-competent children) become uncooperative, or present signs of stress or distress, researchers should regard this as a refusal to take part in a procedure [9]. Researchers might make reasonable attempts to entice the participants to engage with the procedure again at a later stage, but should immediately desist if the participants' negative response persists.

### ***3. Doing research that is relevant to participants and consistent with their welfare***

- Individual animals (as well as vulnerable humans such as very young children) should be involved in research practices only when these have the potential to generate scientific understanding that may be a basis for improvements in the development of animal-centred technology that is relevant to them. More specifically, ACI researchers should only work with animals of a particular group (e.g. species) if the intent is to advance knowledge or develop technology that is directly or indirectly beneficial to the individuals involved in the research as well as other individuals of that group.
- Research procedures that involve the participation of free-living animals should take place in the animals' natural habitat, while those that involve domesticated animals (e.g., companion animals and animals living in farms or zoos) should take place in the animals' familiar settings or, if necessary, in appropriate research facilities, provided that this did not impact negatively on their welfare. Animals should not, under any circumstances, be bred or taken from the wild, and kept in captivity (permanently or temporarily) for the sole purpose of involving them in ACI research activities.

- Whenever possible, researchers should endeavour to design research procedures that can be carried out in the participants' habitual environments and blend in with their living conditions. Researchers working with free-living animals in their natural habitats should seek to minimise interference with individuals as well as the populations and eco-systems of which the individuals are a part. Researchers working with domesticated animals should ensure that their presence and interference is not unwelcome to the individuals involved and any environmental disturbance is kept to a minimum.
- Where it was not appropriate for research activities to be conducted in naturalistic settings and these needed to be conducted within specific research facilities or scientific venues, animals (as well as children) should be accompanied by their legal guardians or legally delegated carers, provided that this did not affect the welfare of the participants or compromise public safety. For the duration of the activities, animals should remain under the supervision of their legal guardians or legally delegated carers or researchers, who should supervise both the interaction of research staff or the public with the animals, and the interaction of the animals with research staff or the public (e.g., a guardian, whose dog was visiting an ACI lab to test a prototype or an ACI venue to demonstrate it, should be able to ensure that researchers or members of the public did not interact with the dog in ways that might cause the dog stress, and that the dog did not behave aggressively). Throughout these interactions, animal welfare and public safety (including the safety of the animals involved) should be the uttermost priority.
- Where visits of non-resident animals were required, research facilities and scientific venues should provide safe and comfortable accommodation, including an appropriate location for retreat and appropriate dietary provisions. Animals should only spend the night within research facilities or scientific venues under the following circumstances: 1) if the animals were already housed at the facilities or venues for other purposes (e.g., mice who already

live in research laboratories to be involved in other research procedures); 2) if the facilities or venues allowed the animals' legal guardians or delegated carers or researchers to spend the night with them, and staying overnight did not negatively affect the welfare of the animals (e.g., an ambient technology installation that could offer comfortable accommodation to both a dog and their human).

#### ***4. Avoiding research procedures that may be harmful to participants***

- ACI practices should ensure an acceptable balance of risk and benefit for animal (as well as human) participants and researchers should protect participants from physiological and psychological harm at all times by employing research methods that are non-invasive, non-oppressive, non-restrictive and non-depriving. The anticipated risks to participants should be negligible, that is resulting at worst in no more than a slight and temporary negative impact (e.g., if a dog tested an interface which momentarily frustrated them through unintentional excessive complication in the design). Under no circumstances should the welfare standards afforded by ACI practices ever fall below the welfare standards envisaged by frameworks such as the British Animal Welfare Act 2006 [6], or equivalent frameworks in other countries.
- ACI research practices should never have the potential effect of causing animal participants pain, suffering, distress or lasting harm [5]. Pain, suffering, distress and lasting harm encompass any material disturbance to normal health (defined as the physiological and psychological and social well-being of the animal) [5]. This also includes disease, injury, and physiological or psychological discomfort, whether immediately (such as at the time of an injection), or in the longer term (such as the consequences of the application of a carcinogen) [5]. In other words, ACI practices should never be such that they require regulation under frameworks such as the British Animals (Scientific Procedures) Act 1986 and Amendment Regulations 2012 [5], or equivalent frameworks in other countries.

- ACI research practices conducted in the wild should never involve the intentional killing, injuring or taking of animals, as well as the possession or control of live or dead animals, their parts or derivatives (including selling, offering for sale, or possessing or transporting for the purpose of selling them) [7]. This also includes damage to, destruction of, or obstruction of access to any structure or place used by animals for shelter or protection, or even simply disturbance of animals occupying such structure or place [7]. In other words, ACI practices should never be such that they require regulation under frameworks such as the British Wildlife and Countryside Act 1981 [7] or equivalent frameworks in other countries.
- ACI researchers might need to combine their own research practices with procedures that imply a higher level of risk for individual participants, in order to develop technology that can ultimately benefit them. However, this should only be the case under either of the following conditions: 1) if such higher risk procedures were necessary for the welfare of individual participants (e.g., the ACI researcher might incorporate an ACI procedure into an animal's visit to a veterinary practice for diagnostic or therapeutic purposes); 2) if such higher risk procedures were already part of individual participants' daily life and habitual experience (e.g., the ACI researcher might analyse the functionalities of a conditioning chamber habitually used by a group of mice in behavioural studies for the purpose of suggesting improvements to the usability of the device). In either case, such higher risk procedures should never be carried out by ACI researchers.
- Researchers should always take into account the cumulative effects of research procedures, possibly associated with other procedures (e.g. husbandry), on individual participants. They should ensure that such cumulative effects do not cause the research procedures to impact on the participants to the extent that welfare standards fall below those envisaged by frameworks such as the British Animal Welfare Act 2006 [6], or equivalent frameworks in



other countries; or cause unregulated procedures (e.g., a visit to the vet) to require regulation under frameworks such as the British Animals (Scientific Procedures) Act 1986 and Amendment Regulations 2012 [5], or Wildlife and Countryside Act 1981 [6], or equivalent frameworks in other countries.

- Under no circumstances should the animals recruited to take part in ACI research ever be used in scientific procedures that do not fully comply with the ethical principles of animal-centred research.

### ***5. Assessing research proposals and obtaining expert support***

- A competent, independent scientific and ethical review body should assess and approve any research proposal before an ACI research project or activity commences, in order to ensure that the research design appropriately meets both scientific and ethical standards.
- The competent scientific and ethical review body assessing the research proposal should ensure that the research team has direct access to the appropriate animal welfare expertise so that any welfare issues that might emerge during the research are promptly recognised and properly addressed. Whenever deemed necessary by the ethical review body assessing the research proposal, ACI researchers should receive appropriate training before undertaking the research envisaged by the proposal under review.
- If, during the research, researchers become concerned for the safety and welfare of a participant (animal or human), they should promptly seek advice from the competent ethical and scientific review body within their research institution as to how the case should be dealt with and whether it should be reported to the relevant authorities.

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**Highlights**

Propose an animal-centred ethical framework to support ACI development

Articulate the implications of a welfare-centred ethical approach

Define criteria for obtaining animals' *mediated* and *contingent consent*

Put forward a series of practical principles for conducting ACI research

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